Design and Construction of Multipurpose Grating Machine for Household and Micro/Small-Scale Business with Electric Motor

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Abstract. The accuracy and speed of preparation of raw materials was one of the keys to the success of a food processing business during the Pandemic and digital era. Mini multipurpose grating machine that was effective, efficient and hygienic was a tool for processed food production needed by micro and small scale businesses to win the competition in the era of on-line business. The purpose of this research was to design a mini multipurpose grating machine that can be used by micro and small scale processed food producers with a compact and simple design, made of food grade stainless steel material, and easy to maintain. This design produced a mini multipurpose grating with specifications of 1,550 mm in length, 900 mm in width, 2,100 mm in height and ±3 kg in weight. The small main drive motor was the advantage of the machine so that it is light and compact which can be placed under the grater cylinder. The results of the performance test showed that the working capacity of grating for coconut was 2.56 kg/h with an efficiency of 95.54%. The mini multipurpose grater machine was easy to carry and can be used for coconut, cassava, sweet potato, carrot, ginger and other similar commodities, which were used as raw materials for processed food on a micro and small scale.

Keywords: Mini multipurpose grating machine · Effective · Efficient and hygienic · Micro and small businesses

1 Introduction

Indonesia is an agrarian country, where most of the population lives in agriculture. Most of the agricultural products cannot be directly consumed, they must be processed/processed first. The quality of these processed products is influenced by processing equipment and machinery. One of the processing tools and machines is a grater machine. The grating machine is one of the machine products resulting from technology that functions as a tool for crushing fruit flesh into small granules [1].

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Grating rasping is a process of reducing size. According to Henderson and Perry in Darma [2], size reduction includes the process of cutting, breaking, rolling and milling. The process of reducing the size of the material is usually done mechanically without changing the chemical properties of the material. Materials that are reduced in size are classified into three classes based on the degree of fineness, namely: (1) dimension range, ie grains measuring about 3.175 mm or more. This size group can still be measured accurately and the surface geometry is easy to see. (2) the sieve range, ie grains with a size of 3.175 mm to 0.0737 mm, and (3) the macroscopic range, namely grains with a size of less than 0.0737 mm. When viewed from the size, grated sago is included in the sieve range group.

The working capacity of the grater and other reducing size machines is determined by the power required per unit of material, the size and shape of the material before and after reduction, the capacity, and the final size range of the material. While the amount of power or energy required is influenced by the type of material, moisture content, particle fineness to be achieved, feed rate, and equipment condition [2]. According to Hixon et al. [3], the size reduction process depends on the properties of the material and the characteristics of the tool or machine used. Material properties that affect the size reduction process include toughness, brittleness, abrasiveness, fide size, adhesiveness, form and structure, and density [4].

The cutting process in multiple cutting blades such as grating is influenced by the size and number and arrangement of the cutting blades. The larger the size of the cutting edge, the greater the force required for the cutting process and the larger the size of the cutting result. Likewise, with cutting teeth, the force required is the more the number of cutting teeth, the greater the force required and the smaller the result of cutting the material.

Design is the calculation of the size and shape of the parts of a system to achieve the desired performance [5]. Added by Cochin and Plass [6], the selection of materials and components that will be used in a system includes a design activity. Norton defines design as the application of various engineering and scientific principles for the purpose of defining a device, process, or system so that it can be realized [7]. While the analysis is a determination of the behavior of the system including the calculation of the response given to a certain input. Designing a system is a "trial and error" procedure. By guessing a design and then observing it to see if its performance matches the desired specifications or not [5].

According to Ulman [8], there are four basic steps that must be taken in designing a system, namely: (1) knowing the problem to be solved (establish need), (2) understanding the problem, (3) selecting alternative problem solving (generate potential solutions), (4) evaluation of the alternatives taken and decide which one is the best. Meanwhile, according to Norton [7], the design process consists of 10 stages, namely: (1) identification of needs, (2) collecting relevant information, (3) stating goals (goal statements), (4) determining specifications, (5) ideation and invention, (6) analysis, (7) selection (8) detailed design, (9) prototyping and testing, (10) production. There are several requirements that must be considered in designing an equipment, among others, are: a. Tools needed by the community b. Technically it can be made c. Economically accountable d. Politically acceptable e. The materials needed are easily available f. Easy to operate.

The grater machine circulating in the community is a large grater machine with a gasoline motor as the driving force. To meet the need for grating at the household and small business level, tools and grating machines are needed that are light, easy to carry (handy) and suitable for processing food (food grade). In the design of this coconut grater machine, it refers to the gasoline engine coconut grater. However, the process is modified to be simpler and uses a small electric motor. The purpose of the design of this versatile grating machine is to design a grating machine that can be used to grate agricultural products, has a simple, inexpensive, easy to operate and maintain system, and can process agricultural products into food (food grade), and to support the development of machine technology. Scars that already exist in the community and small industries.

2 Methodology

2.1 Design Flowchart

Before making the grating machine, the design of the grating machine was carried out. The flow chart for the design of the versatile grating machine can be seen in Fig. 1.

2.2 Tools and Materials

The materials used are food grade 316 stainless steel plate frame, 120 W mini 1 phase electric motor, food grade grater cylinder, pulley, belt, axle, bolts, and cables, while the equipment used is design equipment in the form of Solidworks 2013 application. And workshop equipment in the form of portable spot welding, bending machines, ring wrenches, screwdrivers, and other equipment.

2.3 Functional Design

Each component part of the versatile grating machine has a different function which in the end becomes a binding unit. The components of the versatile grating machine are as follows:

2.3.1 Hopper

Hopper serves as a place to enter the commodity to be grated (coconut, cassava, carrots, etc.). The hopper is located on the side of the grater cylinder, so that the material entering the hopper will be forwarded to the grater cylinder due to the influence of the rotation of the grater cylinder.

2.3.2 Unloading

The grated product will be accommodated by unloading and forwarded to the grated storage container. This stage also serves to prevent the grated from spreading from the grated cylinder.

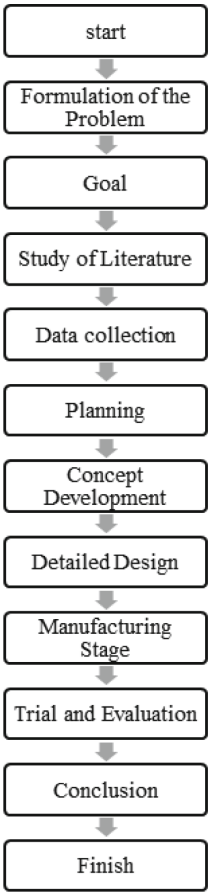

Fig. 1. Multipurpose grate machine design flowchart.

2.3.3 The Grater Cylinder

The grater cylinder is the main component of the multipurpose grater machine, functioning as a cutting knife or grater for agricultural products.

2.3.4 The Driving Force

The driving force used is a 100 W mini 1 phase electric motor which functions to move the grate cylinder through the belt and pulley transmission system.

2.3.5 The Transmission System

The transmission system of the multipurpose grater machine consists of several components, including (1) Shaft: serves to transmit rotation from the electric motor shaft to the cutting blade shaft; (2) Pulley (pulley): serves to seat the belt, in addition to the size of the diameter of the different pulleys can increase or decrease the engine rotation

speed; (3) Belt v-belt: serves to channel the rotation of the pulley on the electric motor to the pulley on the cylindrical shaft of the grate. The length is adjusted to the distance between the pulleys used; (4) Bearings: function as axle/axle mounts.

2.3.6 Engine Frame

The frame serves as a holder for the grater cylinder, the driving motor, and other supporting components. As a basic component and the main seat of the machine, the frame must be strong enough to withstand heavy loads and vibrations from the machine when it is operated.

2.4 Structural Design

Structurally the multipurpose grating machine and its constituent components are as follows:

2.4.1 Hopper

Hopper is made of stainless steel plate (316-food grade), 2 mm thick.

2.4.2 Unloading

Unloading is made of stainless steel plate which is designed to follow the width of the hopper and based on the angle of response of the grater which is at a slope of 45°.

2.4.3 The Grater Cylinder

The grater cylinder is the main component of a multipurpose grater. The grater cylinder and grater eye are made of food grade 316 stainless steel. In the center of the grated cylinder there is a shaft mounted on a bearing placed on the engine frame. On one side of the cylindrical axis of the grate, a pulley is attached which is connected to the driving motor through a belt.

2.4.4 Transmission System

The drive motor will drive pulley 1 which is connected directly to the drive motor shaft and the belt is connected to pulley 2 which is connected directly to the grate cylinder shaft. The grate cylinder will rotate counterclockwise.

2.4.5 The Machine Frame

The machine frame is made using stainless steel. The machine frame is designed to match the dimensions of the grate cylinder and the dimensions of the intake and exhaust hoppers. The engine frame serves as a cylindrical shaft holder and is parallel to the shredded commodity intake section.

2.5 Testing Analysis

2.5.1 Effective Capacity of Grating (kg/h)

According to Oriaku, et al. [9], the effective capacity of the grater is calculated by directly weighing the commodity to be grated, in this test the material used is coconut (kg) divided by the time required for grating (hours), which is expressed through Eq. (1), as follows:

$$\text{KEP} = \frac{\text{m}}{\text{t}} \tag{1}$$

where,
KEP = Effective capacity of grating (kg/h);
m = the weight of the commodity to be shredded (kg);
t = grating time (hour).

2.6 Grating Efficiency (%)

According to Oriaku, et al. [9], grating efficiency is the ratio between the weight of the commodity to be grated with the weight of the grated product. The grating efficiency is calculated using Eq. (2):

$$Ef = \frac{m\_awal}{m\_akhir} \times 100\% \tag{2}$$

where,
Ef = efficiency (%);
m_awal = initial weight of the commodity to be shredded (kg);
m_akhir = heavy after grated (kg).

3 Results

3.1 Multipurpose Grate Machine Prototype

This versatile grater machine can be used to grate agricultural commodities whose flesh needs to be crushed into small grains such as: coconut, carrots, cassava, sweet potatoes, and others. The weight of this versatile grating machine is approximately 3 kg so it is easy to carry, use and maintain (portable) as shown in Fig. 2.

3.1.1 Hopper

The feeder section serves to enter agricultural commodities to be grated. The feeder part is made of food grade stainless steel plate 2 mm thick, feeder width is 103 mm. The feeder part of the multipurpose grating machine can be seen in Fig. 3.

3.1.2 Grater Part

The grater is cylindrical horizontally. On the surface of the grater cylinder there are grater teeth attached to the cylinder. The material used is SUS 316 stainless as shown in Fig. 4.

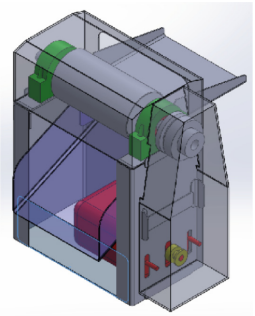

Fig. 2. Multipurpose grating machine prototype.

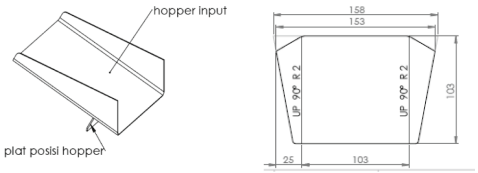

Fig. 3. Hopper.

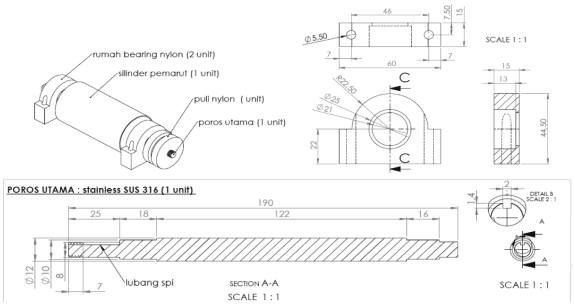

Fig. 4. Grate part.

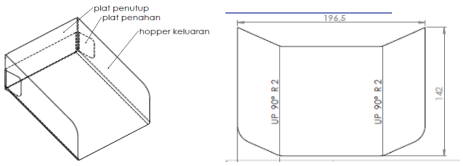

Fig. 5. Unloading.

3.1.3 Unloading

The dispensing part is in the form of a funnel, which functions as the output of the grated product (Fig. 5).

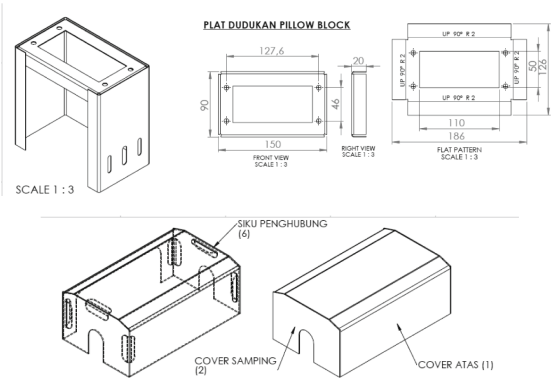

Fig. 6. Frame and Cover Parts.

Fig. 7. Drive motor.

3.1.4 Frame and Cover Parts

The frame part serves to seat various components or attach other components, while the cover is to protect the grater cylinder so that the grated results are not scattered. For the design of the frame and cover can be seen in Fig. 6.

3.1.5 Drive Motor

The motor used in this versatile grating machine has the following specifications (Fig. 7):

Merk	Sewing Machine Motor
Model	HF-1026 N
Watt	100 W
Volt	220 V
Rotation	6000 Rpm

3.2 Performance Test of Multipurpose Grate Machine

The performance test on this versatile grating machine was carried out by calculating the effective grating capacity (PE) and grating efficiency (EP). In this performance test,

Table 1. Multipurpose grate machine performance test

Ulangan	Whole Weight (gram)	Weight After Grating (gram)	Grating Time (sec)	Capacity (gr/s)	Capacity (kg/h)	Efficiency (%)
A	453	423	613	0,74	2,66	93,38
B	465	447	667	0,70	2,51	96,13
C	406	395	583	0,70	2,51	97,29
Total	1324	1265	1863	0,71	2,56	95,54
Average	441,33	421,67	621,00	0,71	2,56	95,54

the agricultural commodity used is coconut. For effective grating capacity of 2.56 kg/h and grating efficiency of 95.54%. The results of the performance test measurements are shown in Table 1.

4 Conclusion

Versatile grating machine was designed to be used in household and micro/small industry. This grater machine was easy to carry (handy), lightweight with dimensions of 1,550 mm in length, 900 mm in width, 2,100 mm in height and a weight of approximately 3 kg. This portable multipurpose grater also had an effective grating capacity of 2.56 kg/h and a grating efficiency of 95.54%. For further development for higher efficiency, it is necessary to improve the hopper so that it is enlarged so that the grater is not wasted.

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